



# JURNAL TEKNOLOGI MAKLUMAT DAN SAINS KUANTITATIF

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## LEMBAGA PENYUNTING

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Prof. Madya Dr. Adnan Ahmad  
Dekan Fakulti Teknologi Maklumat dan  
Sains Kuantitatif

### **Ketua Penyunting**

Prof. Dr. Mohd Sahar Sawiran

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Prof. Madya Dr. Mazani Manaf  
Puan Zahrah Hj Abdul Razak

### **Penyunting Luaran**

Prof. Madya Dr. Khairuddin Omar  
Jabatan Sains dan Pengurusan Sistem  
Fakulti Teknologi dan Sains Maklumat, UKM Bangi  
E-mail: kjts@ftms.ukm.my

Prof. Madya Dr. Tahir Ahmad  
Jabatan Matematik  
Fakulti Sains, UTM Skudai  
E-mail: tahir\_@hotmail.com

Prof. Madya Dr. Hapsah Midi  
Jabatan Matematik  
Faculty of Science and Environmental Studies,  
UPM Serdang  
E-mail: habshah@fsas.upm.edu.my

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Fakulti Teknologi Maklumat dan Sains Kuantitatif  
UITM Shah Alam

Tel                    **03-5543 5329**  
Faks                 **03-5543 5501**  
e-mail              mshahar@tmsk.uitm.edu.my

## DARI MEJA KETUA PENYUNTING

Alhamdulillah, dapat kita terbitkan Jurnal Teknologi Maklumat dan Sains Kuantitatif Jilid 7, Bil.1, 2005. Saya rasa pencinta ilmu menanti-nanti terbitan kali ini.

Seperti biasa jurnal terbitan sesuatu tahun itu, hanya dapat dihantar untuk percetakan dua atau tiga bulan berikutnya. Kadangkala, penulis yang telah menghantar balik artikel yang telah diwasitkan itu tertunggu-tunggu juga adakah artikelnya diterbitkan kali ini. Sememangnya pihak penyunting mengamalkan prinsip giliran FIFO (first in first out), tetapi kadangkala ianya tidak boleh dilakukan. Ini kerana sesuatu bidang pengkhususan itu mempunyai dua atau tiga artikel sekaligus. Jadi pihak penyunting berkemungkinan akan melewatkan salah satu daripada artikel sebidang itu kemudian. Justeru itu, giliran FIFO masih dilakukan dalam bidang yang sama.

Dalam keluaran yang lepas, saya ada mengatakan bahawa minat penulis akan terhakis apabila maklumbalas tentang penerimaan sesuatu artikel untuk diterbitkan itu lambat. Saya hanya boleh memberi nasihat kepada penulis supaya bersabar, sebab ini bergantung kepada pewasit yang menilai itu sibuk atau tidak, sanggup atau tidak dan sebagainya. Percayalah, kesabaran itu akan menjadi kita penulis yang berdisiplin.

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## **Quantifying Consensus On Women's Roles Using Fuzzy Logic**

<sup>1</sup>Puzziawati Ab Ghani and <sup>2</sup>Abdul Aziz Jemain

<sup>1</sup>Department of Statistics, Faculty of Information Technology & Quantitative Sciences,  
Universiti Teknologi MARA, 40450 Shah Alam, Selangor.

<sup>2</sup>School of Mathematical Sciences, Faculty of Science and Technology,  
Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor.

E-mail: <sup>1</sup>puzzi@tmsk.uitm.edu.my, <sup>2</sup>azizj@pkriscc.ukm.my

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### **Abstract**

With greater access to education and rapid economic development coupled with higher costs of living especially in the urban areas, women are left with no choice but to look for and remain in employment. Women in urban society face more challenges in lives and shoulder multiple roles. The juggling act of balancing between work and family commitments that results in role conflict often drives women to favour one role over the other. What women put as their priority is crucial to the smooth running of family institution, which serves as a basic aspect of family happiness in securing the quality of life. This paper attempts to elucidate what are in the minds of working women when they make decision by investigating the consensus on their role priority. A fuzzy logic approach based on a fuzzy majority concept is employed. The data used are based on a case study among women academicians and supporting staff of Universiti Teknologi MARA in Shah Alam. The study shows that women's role priority still lies within the family domain/sphere.

*Keywords: Consensus; Fuzzy Logic; Quality of Life; Women's Roles.*

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### **1. Introduction**

Urban societies face more rapid socio-economic development compared to their rural counterpart. Developments in general and urbanization in particular have brought many changes and challenges to our society and women particularly feel these challenges. Besides being educated and having gained greater access to employment opportunities, the financial needs to foster the economic well-being of urban life drives large majority of women in the urban society to participate in the labour force. Majority of women in urban areas are working mothers who help supplement the family income. Undeniably, these women are not only contributing financially to their families but also contribute towards urban development.

One of the major urban development strategies in Malaysia has been to promote a better quality of life for the urban society. Quality of life need not only be measured from the normal social indicators as reflected in infant mortality rates, doctors per 10,000 population, literacy rates, access to piped water and electricity through the provision of adequate physical and social infrastructure facilities and basic amenities with up-to-date facilities but must also be looked from the perspective of well-managed family institutions. Quintessentially, a well-managed family institution engenders family happiness, one aspect of quality of life. In attaining this, women play a vital role since they are the main actors of family institutions.

The roles women play have been a major concern to many people in our society, especially among those living in the urban areas. Unfortunately, not many empirical studies have been conducted in this country pertaining to this issue. This paper serves as an initial stage that can provide a useful guideline for further studies. It is important to look into this issue so that we can provide a good and quality environment for the lives of women and their families. Women's multiple roles have been well discussed in the western literature as well as ours. Women's participation in the workforce demands them to juggle between work and family commitments. In addition to that working women are also expected to deliver their contributions to the society. Consequently, women are burdened with multiple roles. Balancing well, especially between career and family is key factor to the orderly running of family institutions as well as organizations where women work. This will indirectly nurture good quality of life.

The climate of change brought about by rapid, recent economic advancement where women are directly involved inevitably poses questions of roles priority. For women in particular and society in general, the 'what is in the mind of women during the act of juggling and balancing the roles and what is the priority of working women' questions contain an important message that needs to be properly translated. In this respect, the paper attempts to elicit working women's role priority- the role played in ensuring the smooth running of their daily lives.

We will identify unanimous roles priority among working women. Women's role priority is elicited through criteria normally weighed by working women in their decision-makings. These criteria are normally pertaining to their career and family commitments. Fuzzy consensus based on the concept of fuzzy majority via fuzzy logic with linguistic quantifiers will be employed to identify the role priority. The data used is based on a case study conducted to 340 women academics and supporting staff of Universiti Teknologi MARA in Shah Alam.

The first section of this paper discusses briefly about women's multiple roles and how these roles are viewed as criteria in women's decision-making. The next section concentrates on the modeling of fuzzy consensus followed by sections on data description, results and discussion, and some concluding remarks.

## **2. Women's Multiple Roles**

With more educated and trained women in the country and the increasing demand for female labour in the manufacturing and services sectors and in view of the higher costs of living especially in the urban areas, women are left with no choice but to look for and remain in employment. Besides the need to participate in the economic sector, women are encouraged to involve themselves in family

and community development programmes. More women have realized that self-fulfilment can no longer be solely confined to their homes and their traditional roles of housekeeping and child rearing.

Being in paid work requires women to shoulder multiple roles responsibility as paid workers and as mothers. The multiple-role demands often give rise to role-conflict - a conflict between a life centered on an employment career and the demands of continuous, full-time jobs, and a life centered on marriage, child-bearing and child-rearing, and the demands of family life (Hakim, 2000) which causes women to face the dilemma of balancing between work and family commitments (Perry-Jenkins et al., 2000). According to Thoits (1992) (as cited in Perry-Jenkins, 2000: 990) and Callero (1985), role systems are inherently hierarchical as assumed by role theorists and the problem of juggling roles requires favoring of one role over another. Thus, in the process of making any decision roles priority must have come into place in the minds of women.

Puzziawati et al. (2002) view women's multiple roles from four main perspectives: economic, domestic, social and feminine. In their work nine criteria (refer to Table 1) normally weighed by working women in their decision-making were formulated based on the integration of women's multiple roles and issues related to women and work. From each perspective, one or more criteria were identified (economic perspective – career development, income and career benefits; domestic – family, reproductive aspect and household management; social – social commitments and extended family commitments; feminine – indulging in self-activities). In this paper, consensus on role priority of working women will be elucidated based on the nine criteria.

Table 1: The nine formulated criteria based on women's multiple roles

Label	Criterion
C1	A criterion associated with career development
C2	A criterion associated with familial aspect
C3	A criterion associated with indulging in self-activities (feminine aspect)
C4	A criterion associated with income
C5	A criterion associated with social commitments
C6	A criterion associated with reproductive aspect (family planning)
C7	A criterion associated with extended family commitments
C8	A criterion associated with career benefits
C9	A criterion associated with household management

Source: Puzziawati et al. (2002)

### 3. Methodology

#### 3.1 A Brief Description of Fuzzy Sets and Fuzzy Logic

As elaborated in Bojadziev and Bojadziev (1999: 32), the formal development of set theory began in the late 19th century with the work of George Cantor (1845 – 1918). Since then set theory has been used to establish the foundations of mathematics and modern methods of mathematical proof.

Cantor's sets are crisp where each element under consideration either belongs to a set or it does not. In this case the boundary of a set is rigid and well defined. Nevertheless, in reality things are rather fuzzy than crisp. Zadeh (1965) introduced the concept of fuzziness in the form of fuzzy sets.

A fuzzy set  $A$  is defined by a set or ordered pairs, a binary relation  $A = \{(x, \mu_A(x)) \mid x \in A, \mu_A(x) \in [0,1]\}$  where  $\mu_A(x)$  is a function called membership function;  $\mu_A(x)$  specifies the grade or degree to which any element  $x$  in  $A$  belongs to the fuzzy set  $A$ . The above equation associates with each element  $x$  in  $A$  a real number  $\mu_A(x)$  in the interval  $[0,1]$ , which is assigned to  $x$ . Larger values of  $\mu_A(x)$  indicate higher degrees of membership.

Fuzzy sets and fuzzy relations play an important role in fuzzy logic. Fuzziness in fuzzy logic is associated with the concept of graded membership that can be interpreted as degree of truth. According to Bojadziev and Bojadziev (1999), fuzzy logic stems from the inability of classical logic to capture the vague language, common sense reasoning and problem-solving heuristic used by people in their every day discourse. Fuzzy logic deals with objects that are a matter of degree with all the possible grades of truth between "yes" and "no". Bojadziev and Bojadziev viewed fuzzy logic as a broad conceptual framework encompassing the classical logic that divides the world on the basis of "yes" and "no".

Traditional or classical modeling techniques usually do not incarcerate the nature of complex systems, especially when humans are involved. On the contrary, fuzzy logic is an effective tool for modeling, in the absence of complete and precise information, complex business, decision-making, and management systems. The objects under study in fuzzy logic declare of degrees expressed by the membership function of fuzzy sets.

Fuzzy logic provides a methodology for dealing with linguistic variables and describing modifiers like very, fairly, not, etc. It facilitates common sense reasoning with imprecise and vague propositions dealing with natural language and serves as a basis for decision analysis and control actions (Bojadziev and Bojadziev, 1999).

### **3.2 The Mathematics of Fuzzy Consensus**

The natural extension of general decision-making scheme is to assume multiple decision makers. One of the basic elements underlying group decision-making is the concept of majority. The use of fuzzy linguistic quantifiers exemplified by 'most', 'almost all' represents a fuzzy majority. In many cases, fuzzy majority is closer to a real human perception of the very essence of majority (Kacprzyk et al. 1992) and the concept has been employed in group decision-making by many scholars (Chiclana et al. 2002, 1998, 1996; Tanino 1990, 1984). Traditionally, majority is defined as a threshold number (crisp) of individuals. The fuzzy logic initiated by Prof. Lotfi A. Zadeh imparts a formal handling of a fuzzy majority, which is not possible through the conventional approach.

According to Zadeh (1983), a fuzzy linguistic quantifier  $Q$  is assumed to be a fuzzy set defined in a set  $[0,1]$ . In the case where  $Q$  = 'most' is given by the following mathematical equation:

$$\mu_{\text{most}}(x) = \begin{cases} 0 & \text{for } x < 0.3 \\ 2x - 0.6 & \text{for } 0.3 < x < 0.8 \\ 1 & \text{for } x > 0.8 \end{cases} \quad (1)$$

According to Kacprzyk, the above equation can be interpreted as follows: if at least 80% of some elements satisfy a property, then most of them certainly (to degree 1) satisfy it, when less than 30% of them satisfy it, then most of them certainly do not satisfy it (satisfy to degree 0), and between 30% and 80% - the more of them satisfy it, the higher the degree of satisfaction by most of the elements.

Suppose we have a set of  $k$  options (criteria)  $X = \{x_1, x_2, \dots, x_k\}$  and  $n$  individuals. Each individual  $m$ ,  $m=1,2,\dots,n$ , provides his or her own preferences over  $X$ . Preferences can be expressed in several forms such as ranking/ordering, utility values and in linguistic expressions. In this paper criteria preferences are expressed in terms of utility values. The utility value for criterion  $x_j$  given by individual  $P_m$  is denoted by  $u_{mj}$ . The higher the utility value, the more important is  $x_j$  to individual  $P_m$ .

To obtain a consensus, i.e. a solution that gives an option or a set of options which is best acceptable by the group of individuals as a whole, Kacprzyk proposed two approaches: the direct approach and the indirect approach. This paper will adopt the indirect approach. In the indirect approach, the following steps are undertaken:

- i. Transform individual preferences into fuzzy preference relations and obtain a fuzzy preference relation matrix for each individual,  $P_m = [P_{ij}^m]_{k \times k}$ ,  $i, j = 1, 2, \dots, k$ ;  $m = 1, 2, \dots, n$ , whose elements  $0 \leq P_{ij}^m \leq 1$  are such that the higher  $P_{ij}^m$  the higher the preference of individual  $m$  of  $x_i$  over  $x_j$ . If  $P_{ij}^m = 0$ , it indicates a definite preference of  $x_j$  over  $x_i$  and vice versa for  $P_{ji}^m = 1$ . If  $P_{ij}^m = 0.5$ , then  $x_i$  and  $x_j$  are equally important.  $P_m = [P_{ij}^m]_{k \times k}$  is reciprocal, that is  $P_{ij}^m + P_{ji}^m = 1$ . The utility values are transformed to preference relations via the following equation:

$$P_{ij}^m = \frac{(u_{mi})^2}{(u_{mi})^2 + (u_{mj})^2}, \quad 1 \leq i \neq j \leq k \quad (2)$$

- ii. Obtain a social fuzzy preference relation  $P$ , based on  $P_1, P_2, \dots, P_n$ , that represents the preferences of the group as to the particular pairs of criteria. The social fuzzy preference relation  $P = [p_{ij}]$  is given as follows:



$$p_{ij} = \begin{cases} \frac{1}{n} \sum_{m=1}^n \alpha_{ij}^m & \text{for } i \neq j, \\ 0 & \text{for } i = j, \end{cases} \quad i, j = 1, \dots, k, \quad (3)$$

where

$$\alpha_{ij}^m = \begin{cases} 1 & \text{if } P_{ij}^m > 0.5, \\ 0 & \text{otherwise.} \end{cases} \quad i, j = 1, \dots, k; m = 1, \dots, n. \quad (4)$$

- iii. Based on Kacprzyk alternative solution concept, obtain the  $\alpha/Q$ -consensus winner. The  $\alpha/Q$ -consensus winner is defined as a fuzzy set of criteria that are sufficiently (at least to a degree  $\alpha$ ) preferred over  $Q$  other criteria. While the consensus winner is initially defined as  $x_i \in W \Leftrightarrow \forall x_j \neq x_i: p_{ij} > 0.5$ , i.e. criterion  $x_i$  belongs to the set of consensus winners  $W$  if and only if there is no other criterion preferable over  $x_i$  (Nurmi, 1981).

First define the elements of dominance matrix to a degree  $\alpha$ ,  $G(\alpha) = [g_{ij}(\alpha)]$ , which expresses whether  $x_i$  dominates  $x_j$  or not, as follows:

$$g_{ij}(\alpha) = \begin{cases} 1 & \text{if } P_{ij} > \alpha \geq 0.5, \\ 0 & \text{otherwise.} \end{cases} \quad (5)$$

The mean degree to which criterion  $x_i$  is preferred to all other criteria is given in the following equation:

$$g_i(\alpha) = \left\{ \frac{1}{k-1} \sum_{j=1}^k g_{ij}(\alpha) \right. \quad (6)$$

The extent to which  $x_i$  is preferred to  $Q$  ('most') other criteria to a degree  $\alpha$  is

$$z_Q^i(\alpha) = u_Q(g_i(\alpha)) \quad (7)$$

The fuzzy  $\alpha/Q$ -consensus winner as defined by Kacprzyk is as follows:

$$W_{\alpha/Q} = z_Q^1 / x_1 + \dots + z_Q^k / x_k \quad (8)$$

Wherever  $Q$  appears in the equation, fuzzy majority expressed by a fuzzy linguistic quantifier is employed.

In the case where  $P_{ij} > 0$  for all  $i, j = 1, \dots, k$ ,  $P_{ij}/P_{ji}$ , indicates a ratio of preference intensity for criterion  $x_i$  to that of  $x_j$  (Tanino, 1984), i.e. it shows  $x_i$  is  $P_{ij}/P_{ji}$  times as good as  $x_j$ .

### 3.3 The Data

The data collected are ratings of importance of those nine criteria as listed in Table 1. Three hundred and forty randomly selected women academic and supporting staff of Universiti Teknologi MARA rated the importance of the nine listed criteria in their everyday decision-making. Data collection was carried out through personal interviews.

## 4. Results and Discussion

Based on the social fuzzy preference relation matrix (not shown here) that represents the preferences of the whole group of women as to the particular pairs of criteria, a dominance matrix is derived as in Table 2. Value of 1 in the table implies that criterion  $i$  dominates/defeats criterion  $j$  (in other words criterion  $i$  is more important than criterion  $j$ ) and a value of 0 means otherwise. For example along the first row that refers to career as the criterion, it dominates income, social commitments, reproductive aspect and commitments towards extended family. The same pattern of dominance holds true for criteria related to feminine aspect and career benefits.

Table 2: The Dominance Matrix,  $G(0.5) = [g_{ij}(0.5)]$

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1: Career	-	0	0	1	1	1	1	0	0
C2: Familial	1	-	1	1	1	1	1	1	1
C3: Feminine	0	0	-	1	1	1	1	0	0
C4: Income	0	0	0	-	1	0	0	0	0
C5: Social	0	0	0	0	-	0	0	0	0
C6: Reproductive	0	0	0	0	1	-	0	0	0
C7: Ext. family	0	0	0	1	1	0	-	0	0
C8: Benefits	0	0	0	1	1	1	1	-	0
C9: Household	1	0	1	1	1	1	1	0	-

Table 2 also shows that family dominates all other criteria. Household management dominates almost all other criteria except for criteria under familial aspect and career benefits. Income and reproductive aspect only dominate social commitment. Social commitment is dominated by all other criteria.

In view of the fact that family dominates all the other eight criteria, it is of interest to see how much family factor being placed its importance compared to other criteria. Such information can be captured in Figure 1 which shows the ratio of preference intensity for criterion related to familial aspect to that of other criteria. In other words, the figure exemplifies how many times family is more important than each of the other eight criteria.

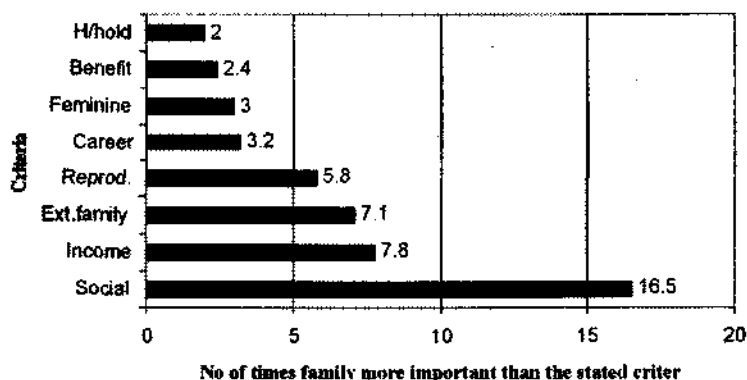


Figure 1: Importance of Familial Aspect Compared to the Stated Criteria

As demonstrated in Figure 1, family aspect is three times more important than career and feminine aspect. This can be translated as follows: for every four decisions that involve family and career or family and feminine aspect, three times will be for the family. Family is about eight times more important than income. The manifestation of this in women's daily lives is common and can be translated as: given the opportunity to earn extra during the weekends, women will only be willing to do it once in every eight weekends. This shows though economic factor seems to be crucial but when it comes to make a choice between family and income, women are willing to sacrifice the monetary drive.

Comparing with extended family commitments, family is seven times more important. This result is reasonable since generally, attending to extended family needs or visiting them once in every eight weeks (two months) is a common practice in our society. Nevertheless, household management is still viewed as priority compared to familial aspect since it is only two times more important. Family factor is almost six times more important than reproductive aspect. This does not necessarily mean that family planning is not that important to working women but it could be due to the fact that this criterion is embedded within the familial aspect.

Unfortunately, social commitment is least in the minds of these women when they make decision since this aspect is very much over-ruled (16.5 times) by family factor. It is as good as saying social commitment is presumably not in the minds of these women especially when they make decision. To a certain extent it might be true to say that most women are not really bothered by what happens outside their home since major activities are focused inside the house. As a whole, when it comes to family as a baseline in the decision-making, these women put top priority to household management followed by career benefits.

Based on the dominance matrix, the fuzzy  $\alpha/Q$ -consensus winner with  $\alpha=0.5$  and  $Q='most'$  is  $W_{0.5/'most'} = 0.4$  (career development), 1.0 (family), 0.4 (feminine), 0.4 (career benefits), 0.9 (household management). This implies that with the consensus degree measures from 0 to 1, the result of this study shows family is important by most women with a consensus

degree of 1. Most women, with a consensus degree of 0.9 also consider household management important. These two aspects are attributes of domestic role.

## **5. Conclusion**

This paper has identified domestic role (family and household aspects) as the most important role to majority of working women. This confirms the notion of no separate sphere between family and work.

Identifying the consensus on role priority of working women is crucial towards sustaining quality of life through a creation of a work system that is able to tolerate women's current needs. What are in the minds of our working women, as a consensus, should be translated properly in formulating suitable policy so that women can contribute to their fullest capacity. There exists tremendous potential in the women that can be tapped and harnessed for development and if we want them to participate and contribute productively and effectively towards developing a perfect urban society, policies for working women must be made adaptable to women's needs.

Based on this case study, it can also be concluded that, as a consensus women are not willing to sacrifice their families and household activities (the domestic role) for others (even their careers) since domestic role is given the top priority.

The central role women play according to their priority will be the enabling factor in sustaining quality of life. The results of this study not only directly provide an insight into what is the top priority of working women unanimously; it also indirectly illuminates women's needs and wants in line with the demand of urban life. These can serve as conspicuous inputs to policy makers, councilors and other relevant authorities in the planning of development programmes particularly for urban society where women play a major role and in the formulation of new policies for women in the working sector. What we want to emphasise is the fact that working women necessitate some form of flexibility in their work environment. If a more women-friendly-family-work-package can be formulated by work organizations in this country, this will allow women to strike a better balance between career and family demands in order to sustain and enjoy a better quality of life.

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## **Biographies**

Puzziawati Ab Ghani obtained her Master of Science in Applied Statistics from Bowling Green State University, Ohio, U.S.A. Since 1988 she has been with Universiti Teknologi MARA, Shah Alam. Her research interest has been in Social Statistics. She is currently working on her PhD thesis in the area of Demography and Multi-criteria Decision Making with the application of fuzzy logic.

Associate Professor Dr Abdul Aziz Jemain is the Chairman, School of Mathematical Sciences, Universiti Kebangsaan Malaysia. He obtained his PhD from University of Reading, UK in Medical Statistics on Cancer Screening, and received his Master of Science in Medical Statistics from London School of Hygiene and Tropical Medicine, U.K. At present, his research interest is in Social Statistics focusing on family issues, gender and aging. His research activities also include Multi-criteria Decision Making, Performance Measurement and Statistical Modeling.